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Laboratory Investigation on Partial Usage of Egg Shell Powder as Cement and Iron Slag as Fine Aggregates

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Abstract: The findings drawn on the basis of numerous laboratory experiments on compressive strength, flexural strength, spilt tensile strength, and ultrasonic pulse velocity indicated that: After a 20 percent replacement of OPC-43 with egg shell waste powder, the compressive strength of concrete tends to decline dramatically. With the amplification of marble waste powder, the rate of decrease is increasing. The 20% replacement of OPC-43 with egg shell powder and 20% replacement of iron slag aggregate have been shown to produce acceptable results. With 20 percent removal of both egg shell waste powder and iron slag aggregate, the specimen had the highest break tensile strength relative to that of handled concrete. Flexural strength findings showed improved specimen strength with ESP replacement of 20 percent. However, more ESP boost would steadily decrease the power. Apart from the concrete blend, where OPC-43 was replaced by 30 percent of Egg shell powder and fine aggregate was replaced by 40 percent of iron slag aggregate, the ultrasonic pulse velocity of control concrete is greater than the ultrasonic pulse velocity of control concrete. Relative to traditional concrete, the strength of concrete prepared with the aid of egg shell powder is more equal because the particles of the egg shell powder were smaller compared to the size of cement, because the particles of egg shell powder slurry densify the concrete by covering all sorts of voids within the concrete.
Keywords: Egg Shell Powder, Iron Slag, Conventional Concrete, Modified Concrete and Mechanical Properties

I. INTRODUCTION

The manufacture of cement and concrete in the field of building has been promoted by the use of agricultural waste or secondary materials. Various sectors are producing new by-products and waste materials. Environmental and wellbeing issues cause the dumping or handling of waste products. Therefore, in the concrete sector, the disposal of waste materials has considerable potential. By-products such as fly ash, silica fume, and slag have been considered as waste materials for many years. Compared to standard concrete, the concrete prepared with such materials demonstrated increases in workability and longevity and was used in power building, chemical plants and underwater structures. Intensive analysis experiments have been conducted over recent decades to investigate all possible strategies of reuse. Construction scrap, blast furnace, steel slag, coal fly ash and bottom ash have been accepted in many areas as substitute aggregates in the manufacture of ordinary Portland cement in embankments, highways, pavements, foundations and building construction. Iron Slag is an industrial by-product substance made from the copper mining process. Around 2.2 tonnes of Iron Slag is produced for every tonne of copper output. It has been estimated that the world copper industry produces roughly 24.6 million tonnes of slag.

[1-4] worked on the encapsulation technique to heal the crack in the cementitious material – Egg Shell Powder. Author has prepared epoxy microcapsule and urea microcapsule to be used in the cementitious material. Author worked with epoxy resin healing agent that is used inside the capsules and placed inside the samples. In the initial stage author focused on the viability of capsules and the size, thermal resistance and texture of the microcapsule. To examine the crack presence and crack filling process, author has conducted the scanning electron microscope test equipped with the energy dispersive x-ray. Three parameters are taken by the author to observe the efficiency of the healing including mechanical property, chloride penetration and healing capacity. [5-8] have worked on the coated pellet system which is useful for self-healing in cementitious material – Egg Shell Powder. Three different minerals are taken by author as healing agent. To use these minerals, pan palletisation was used to produce the pellets. Author has suggested the silica fume and bentonite the most suitable healing agent. Later, these pellets are covered with the capsulation. The coating of the capsulation was done with polyvinyl alcohol. Polyvinyl alcohol was examined for water solubility and in alkaline solution and for many other factors. These various pellets have shown positive results in respect of porosity but less crushing strength. [9-10] Based on waste management created by catastrophe demolition of houses, as well as intuition of construction and renovation. Almost 7-8 million tonnes of concrete and brick waste are produced annually, making it a major problem to dump or use anywhere.

Authors also researched the use of recycled concrete aggregates (RCA) and ESP in self-compacting concrete with the idea of recycling concrete waste (SCC). Recycled coarse aggregates were removed from a house that was 35 years old. Coarse aggregates with percentages is replaced with RCA (0, 25, 50, 75, and 100 percent). With multiple tests such as Slump flow test, J-Ring test, V-Funnel test, fresh concept mix properties were observed. Hardened properties have been tested in various RCA substitutes, such as compressive strength and tensile strength. Slump value & passing capacity were found to decrease with an increase in RCA percentage [11-15].

The use of super plasticizer also increased the flow and filling/passing capability of the SCC control combination as per the EFNARC requirements. Up to 50 percent substitution of standard coarse aggregates with RCA compressive strength decrease was very small, 10-20 percent decrease in SCC compressive strength containing 75 percent, 100 percent RCA was observed compared to SCC containing normal aggregates.

In the case of RCA containing SCC, the tensile strength in the bending test was also lower and a reduction of almost 58 percent was observed at 100 percent CA substitution with RCA relative to the base combination. [16 - 20] High strength SCC was found to be obtainable with natural pozzolanic and other mineral fillers, and these blends have offered a concrete with very low permeability to chloride that met the criterion of less reinforcement corrosion.

The new density metre has also been confirmed. In all blends accept pozzolanic and bag house mud, drying shrinkage was found to be very minor. To increase the strength and longevity of SCCC, the percentage of bag house dust must be reduced. [21-25] Observed the power of the SCC with slag was greater than the reference mix after a span of nearly one year. More sand substitution by slag gave higher intensity with era, but 10 percent substitution led to 4 percent shrinkage and up to 60 percent shrinkage increased to 44 percent with a rise in slag percent.

II. RESEARCH GAP

A. In previous experiments, binary variations of ESP as a percent substitution of cement and iron slag aggregate as a percentage substitution of fine aggregate have not been carried out so far.
B. Minimum work has been done as a percentage replacement of cement and iron slag as fine aggregates for the production of the M-30 concept mix with egg shell waste powder
C. The comparison of the different properties of modified concrete and traditional concrete Egg shell powder & Iron slag aggregate with the aid of the Rebound hammer test has not been achieved so far.
D. There was no concern for the Ultrasonic pulse velocity test on Egg shell powder & Iron slag aggregate modified concrete.

III. OBJECTIVES

Growing and comparing the strength parameters of concrete using Egg shell powder as a partial substitution of cement and Iron slag aggregate as a partial substitution of natural aggregate is the main aim of the current analysis. To achieve this goal certain sub-objectives needs to be considered which are as follows:

A. To study the workability of concrete with the addition of different percentages of Egg shell powder & Iron slag aggregate.
B. To study the mechanical properties of the prepared samples of concrete after 7 days and 28 days.
C. To identify the optimum percentage of the waste ceramic content, from the workability and strength parameters of the prepared samples.

IV. SCOPE OF STUDY

After the strength of the Iron Slag and egg shell are known to be a waste product and the land rose day by day for its disposal showing a significant environmental impact, we are using Iron Slag in the building sector to minimise it. While Iron Slag has many applications, relative to its use in building, only a small percentage.

V. EXPERIMENTAL RESULTS

The primary objective of the study work is to learn the strength parameters of recycled aggregate concrete samples using Egg Shell waste powder as partial cement substitution at 7.5%, 15%, 22.5% and Iron Slag aggregate at 10% and 20% as partial natural coarse aggregate substitution. After casting, the specimens are kept in water for 7 days and 28 days for proper curing. Then all the specimens are tested and the test results are shown further. The following figures showcase the sample casted for testing.

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A. Compressive Strength Test Outcomes

Samples of the scale (150mmX150mmX150mm) were cast and over the past 7 days and 28 days the compressive strength test as per IS: 516-1959 was performed. As compared to all other blends, it was observed that the N3 blend has the highest compressive power. In the table and figure, the compressive strength of all concrete mixes is shown.

Figure– 1: Casted Samples for Hardened properties testing

Table – 1: Compressive Strength Outcomes

Mix	Water- binder ratio	Compressive strength past 7 days(N/mm²)	Compressive strength past 28 days(N/mm²)
N0	0.45	22.35	33.37
N1	0.45	22.69	33.87
N2	0.45	23.20	34.63
N3	**0.45**	**25.08**	**37.44**
N4	0.45	24.81	37.04
N5	0.45	23.66	35.32
N6	0.45	22.19	33.12

Table -2: Flexural Strength Outcomes

Mix	Water- binder ratio	Flexural strength past 7 days(N/mm²)	Flexural strength past 28 days(N/mm²)
N0	0.45	5.19	5.77
N1	0.45	5.22	5.81
N2	0.45	5.29	5.88
N3	0.45	5.49	6.11
N4	0.45	5.47	6.08
N5	0.45	5.34	5.94
N6	0.45	5.17	5.75

Table – 3: Split Tensile Strength Test Results

Mix	Water- binder ratio	Split tensile strength past 7 days(N/mm²)	Split tensile strength past 28 days(N/mm²)
N0	0.45	2.82	4.04
N1	0.45	2.84	4.07
N2	0.45	2.87	4.11
N3	0.45	3.01	4.28
N4	0.45	2.98	4.26
N5	0.45	2.91	4.16
N6	0.45	2.81	4.02

B. *Flexural Strength Test Results*

Several scale beams (500mmX100mmX100mm) were cast after compressive strength test to perform flexural strength test as per IS: 516-1959 for 7 days and 28 days after compressive strength test. The N3 blend has been observed to have greater flexural strength than other mixtures. The flexural strength test results are shown in the table below.

C. *Split Tensile Strength Test Results*

Cylinders of different concrete mixes were cast after completion of the flexural strength test in order to conduct split tensile strength testing in compliance with IS: 5816-1999 for 7 days and 28 days. This test was carried out in order to guarantee the concrete's tensile strength. The N3 mix samples have been found to have higher break tensile strength than other blends, such as N0, N1, N2, N4, N5 and N6. Outcomes of the evaluation and observations are shown in Table.

Table – 4: Tests Results of Rebound Hammer Test

Mix	Average rebound number past 28 days(N/mm²)	Quality of concrete
N0	46.71	Good
N1	47.41	Good
N2	48.48	Good
N3	52.41	Excellent
N4	51.85	Excellent
N5	49.44	Good
N6	46.36	Good

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Table - 5: Ultra-sonic Pulse Velocity Test Results

Mix	Ultrasonic pulse velocity past 28 days(N/mm^2)	Quality of concrete
N0	4.04	Good
N1	4.07	Good
N2	4.11	Good
N3	4.58	Excellent
N4	4.56	Excellent
N5	4.16	Good
N6	4.02	Good

D. Rebound Hammer Test Results

Rebound Hammer test confirming to IS-13311.2-1992is an important test which is used to test the compressive strength of the samples under inaccessible areas. The rebound hammer is also called as Schmidt hammer. Test results are shown in table above.

E. Ultrasonic Pulse Velocity Test Results

An ultrasonic pulse velocity (UPV) test as per IS: 13311.1-1992 is an in-situ, non-destructive type of test that has been used mainly to verify concrete excellence. The 15cmx15cmx15cm specimen was cast and then the ultrasonic pulse velocity test was carried out over it. and Table above. Shows the test findings.

VI. CONCLUSIONS

The following findings are drawn on the basis of numerous laboratory experiments on compressive power, flexural strength, break tensile strength, ultrasonic pulse velocity:

A. After a 20 percent replacement of OPC-43 with egg shell waste powder, the compressive strength of concrete tends to decline dramatically. With the amplification of marble waste powder, the rate of decrease is increasing.

B. The 20% replacement of OPC-43 with egg shell powder and 20% replacement of iron slag aggregate have been shown to produce acceptable results.

C. With 20 percent removal of both egg shell waste powder and iron slag aggregate, the specimen had the highest break tensile strength relative to that of handled concrete.

D. Flexural strength findings showed improved specimen strength with ESP replacement of 20 percent. However, more ESP boost would steadily decrease the power.

E. Apart from the concrete blend, where OPC-43 was replaced by 30 percent of Egg shell powder and fine aggregate was replaced by 40 percent of iron slag aggregate, the ultrasonic pulse velocity of control concrete is greater than the ultrasonic pulse velocity of control concrete.

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